Neutrino Factory: Possible Scenario for Study 3

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Abstract

At the Collaboration meeting held on June 11-12, 2003 at Columbia University, NY., a discussion was started for a possible Study 3 within the context of an International Collaboration.

1 Introduction

Possible scenarios for study3 include the so-called *Neuffer Phase Rotation*[1] with a $180\,\pi$ mm acceptance, followed by a *pre-cooler*, a *sign-divider*, and either, cooling rings[2],[3],[4] or non-cooling at all. The next section is acceleration on FFAG[5] rings with $15\,\pi$ mm acceptance in the first case and $30\,\pi$ mm acceptance in the case of non-cooling. Finally, at the end of the chain is the muon storage ring with one of the straight section pointing to the location of the detector.

Schematics representations are shown in the following three figures 1,2,3. In the next sections of this paper we present preliminary simulations results for some of the options.

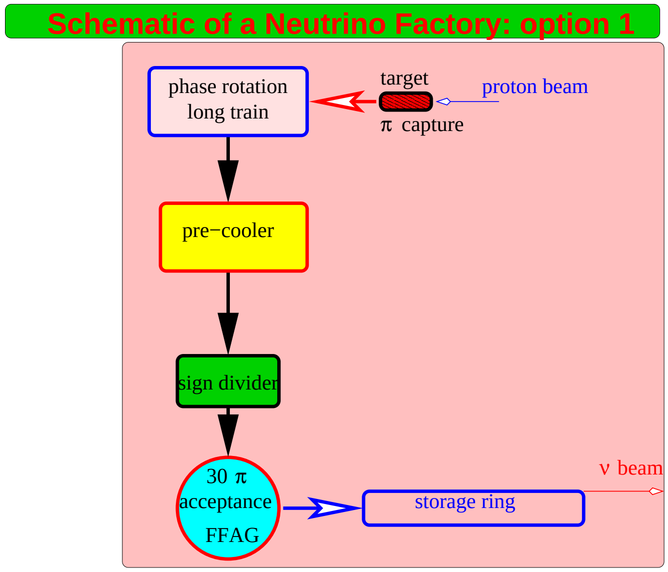

Figure 1: Option-1: Long train pulse with no-cooling needed. The FFAG accelerator has a large acceptance.

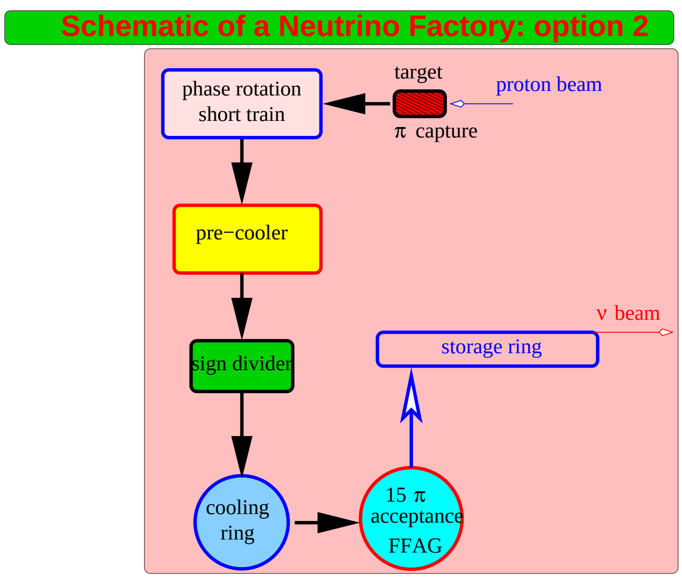

Figure 2: Option-2: Short train pulse, cooling ring and a low acceptance FFAG accelerator.

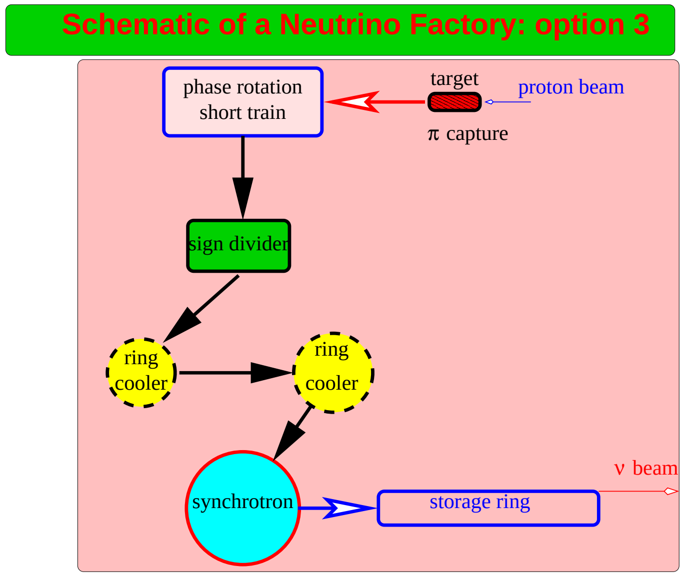

Figure 3: Option 3: This option requires two cooling rings as the acceptance of the fast ramping synchrotron[6] is $4\,\pi$ mm.

2 Capture, Bunching and Phase-Energy Rotation

The scenario known as *Neuffer Phase Rotation* is described in much details in [1]. Here, we present results obtained using the code ICOOL[7] for several examples.

The pion beam is created by a 24 GeV/c proton beam on a H_g jet; the production process is modeled by the code MARS[8]. The longitudinal phase-space plot of the produced π beam is shown in Fig.4. This beam is captured in a solenoidal transport and decay channel.

The *drift* is followed by a *buncher* with 20 cm rf cavities every meter; the focusing is provided by a constant field solenoid.

To adiabatically bunch the beam, the frequency, gradient and phase of the cavities must be functions of the position in the channel.

Following the *buncher* is a phase *rotator* which bring all the bunches to the same (approximately) central total momentum. Next, the beam is matched into a *pre-cooler* before is accelerated.

We have simulated 3 channels with different geometry (see Tb. 1). The profile of B_z on axis is seen in Figs. 5,8.

Table 1: Length of *drift*, *buncher* and *rotator*.

Section	Example-1	Long-train	Short-train
End drift (m)	75	90	45
End buncher	135	150	75
End rotator	183	159	85

The performance of the channels are given in the following sub-sections:

2.1 Example-1

This is the example given in reference [1]

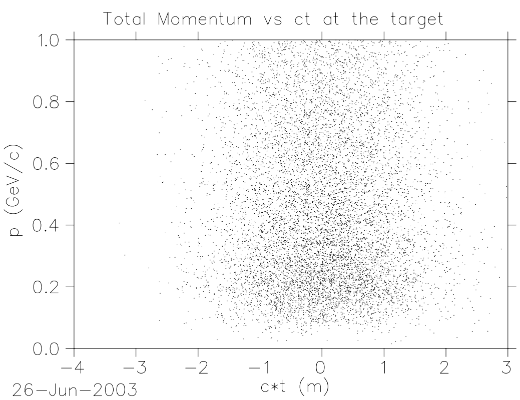

Figure 4: Longitudinal phase space, p *vs* ct, of the MARS generated pions.

The longitudinal phase at the end of the *drift* is depicted in Fig. **??**.

This prescription produces a string of bunches, ≈ 60, separated by $\lambda_{rf} \approx$ 1.5 m corresponding to 200 MHz cavities located at the end of the *buncher*, see Fig. **??**.

In Tb. 2 is listed the beam emittances at each section.

2.2 Long-train

This is beam contains approximately 60 bunches.

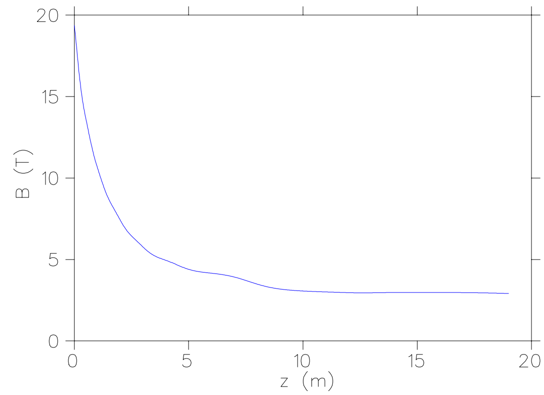

Figure 5: Capture solenoid magnetic field B_z on axis; beyond the first ≈ 19 m the field is constant with value $B_z = 2.915$ T.

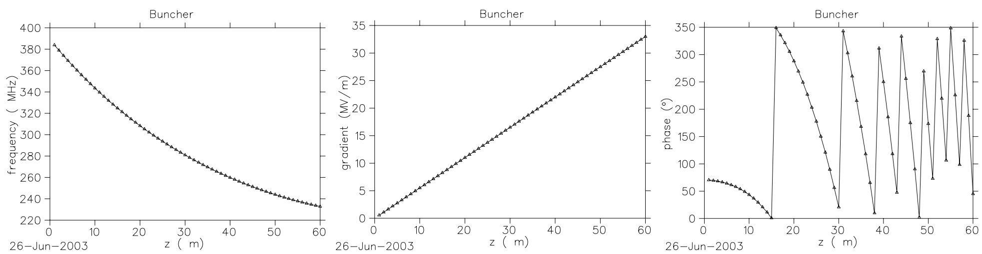

Figure 6: Frequency, gradient and phase *vs.* z

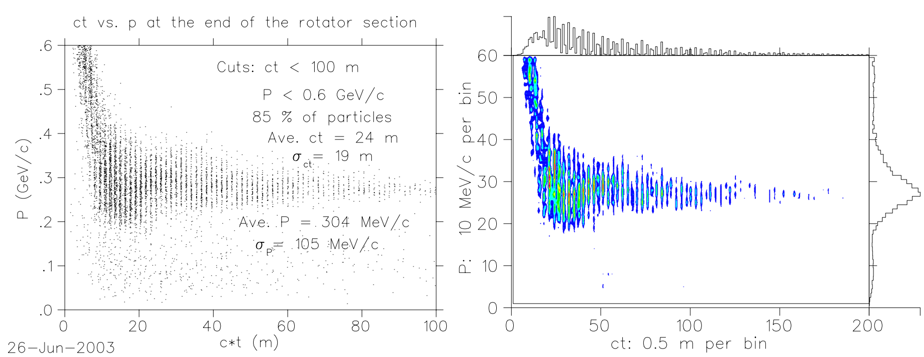

Figure 7: Longitudinal phase space *vs.* z at the end of the *rotator* section.

Table 2: Muon Beam *rms* emittances at the end of the *drift*, end of the *buncher* and end of the *rotator*.

Section	ϵ_T (π mm)	ϵ_L (π mm)	ϵ_6 (π mm^3)
Drift	18.8	633.9	235
Buncher	19.1	637	242
Rotator	19.2	750	283

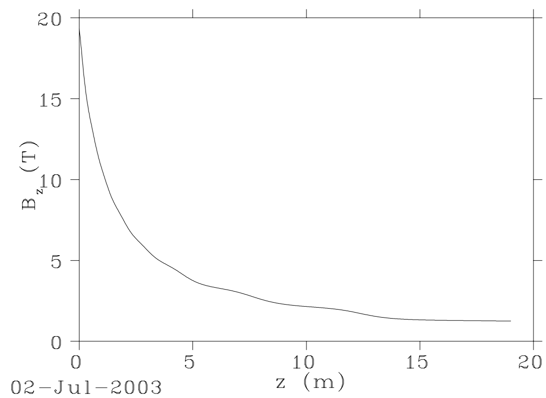

Figure 8: Capture solenoid magnetic field B_z on axis; beyond the first ≈ 19 m the field is constant with value $B_z = 1.25$ T. This field is used in both long and short-train examples.

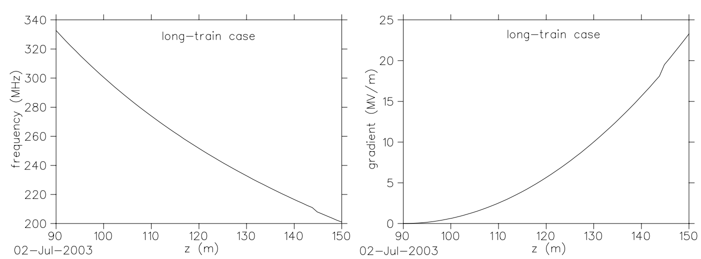

Figure 9: Frequency and gradient *vs.* z

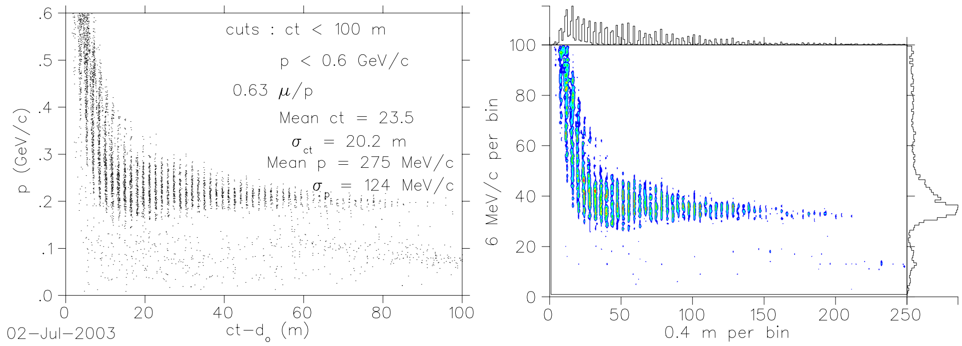

Figure 10: Longitudinal phase space at the end of the *rotator* section.

2.3 Short-train

This beam contains approximately 30 bunches.

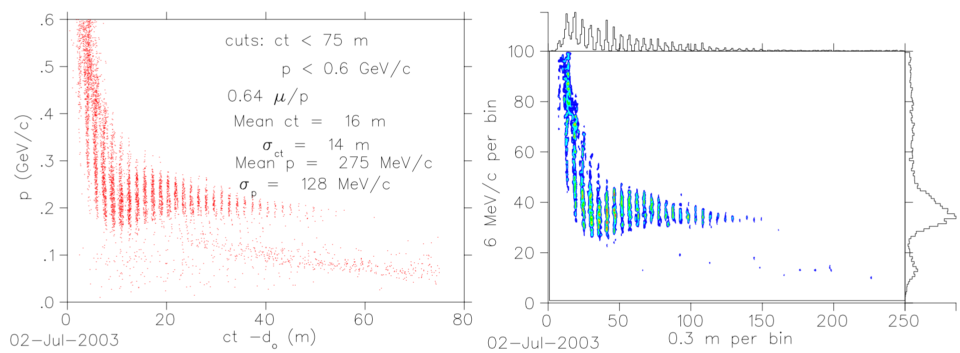

Figure 11: Longitudinal phase space at the end of the *rotator* section.

3 Cooling *à* la Study 2

We refer the reader to the last published MC status report [9] for details of the channel. In this section we present results obtained by matching the beam at the end of the *rotator* into the SFOFO cooling channel.

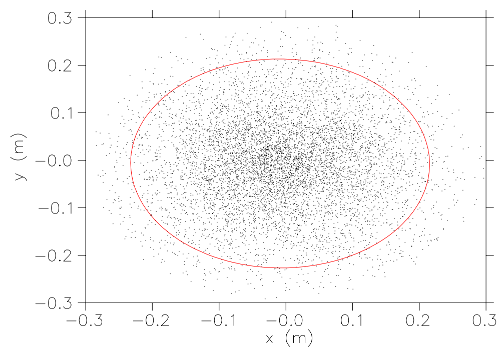

Figure 12: x *vs.* y at the end of the *rotator* section.

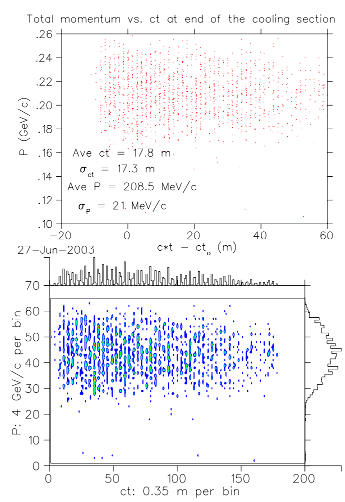

Figure 13: Longitudinal phase space at the end of the cooling section

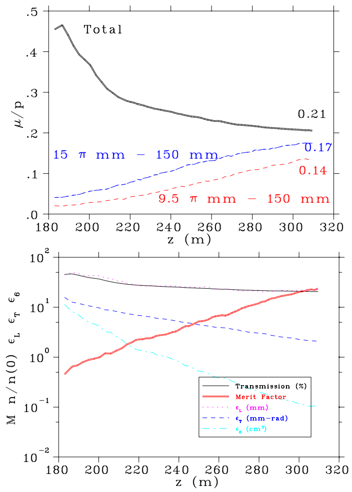

Figure 14: Left: Number of μ/p along the cooling channel; shown are the total number and the fractions into two acceptances: $\epsilon_T = 9.5$ and 15π mm, $\epsilon_L = 150$ mm; right: evolution of the performance, transmission, merit factor and emittances, along the cooling channel.

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References

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